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Completion of One Year Bioventing . . .

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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE TEXAS

24 Feb 95

MEMORANDUM FOR OO-ALC/EMR
ATTN: Mr. Andrew Gemperline
7276 Wardleigh Rd
Hill AFB UT 84056-5127

FROM: HQ AFCEE/ERT
8001 Arnold Drive
Brooks AFB TX 78235-5357

SUBJECT: Completion of One Year Bioventing Tests, Site 388, Site 510.8, Site 1705, and Site 40002

The Air Force Center for Environmental Excellence (AFCEE) one-year bioventing test and evaluation projects at your four sites have been completed. For each site, Figure 1 provides general site information and Table 1 provides a summary of initial, six-month, and one-year fuel respiration and degradation rates measured at several monitoring points. Biodegradation rates have generally remained stable for Sites 388, 510.8, and 40002. These relatively stable degradation rates indicate that soil contamination remains at somewhat elevated levels. Table 2 provides a summary of initial and final soil and soil gas analytical results for total recoverable petroleum hydrocarbons (TRPH) and benzene, toluene, ethyl benzene, and xylenes (BTEX). Based on results from your sites and 121 other sites currently under operation, bioventing is cost-effectively remediating fuel contamination in a reasonable time frame. We recommend its application throughout these sites, and at other sites on your installation using the criteria in the AFCEE Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, May 1992, including Addendum One, February 1994. These are found in the "Tool Box" recently sent to your base.

For Site 1705, all soil gas samples contained elevated oxygen concentrations ranging between 16.8 and 17.6 percent. Field TVH concentrations were low, generally indicating the absence of fuel contamination. However, TRPH was detected at a concentration of 13,200 mg/kg in one soil sample collected from the vent well, indicating that some zones of fuel contaminated soil existed at Site 1705. It is possible that the monitoring point screens were not set in these contaminated zones. The elevated oxygen concentrations in the available soil gas samples did not provide information for calculation of respiration rates for Site 1705.

The objective of the one-year sampling effort was not to collect the large number of samples required for statistical significance. It was conducted to show relative reductions in TRPH and BTEX concentrations. Soil gas samples are somewhat similar to composite samples in that they are collected over a wider area. Thus, they provide a good indication of changes in soil gas profiles and volatile contaminant concentrations (see Addendum One to Test Plan and Technical Protocol for a Field Treatability Test for Bioventing - Using Soil Gas Surveys to Determine Bioventing Feasibility and Natural

Attenuation Potential, February 1994). Soil samples, on the other hand, are discrete point samples subject to large variabilities over small distances/soil types. Given this variability, coupled with known sampling and analytical variabilities, a large number of samples would have to be collected to conclusively determine "real" changes in soil contamination. Because of the limited number of samples, these results should not be viewed as conclusive indicators of bioventing progress or evidence of the success or failure of this technology. In situ respiration tests are considered to be better indicators of hydrocarbon remediation than limited soil sampling.

The soil analytical results for these sites indicated a general decrease in soil contamination. Additionally, soil gas analytical results indicate that a reduction in BTEX has taken place in the soils within the treatment radius of the pilot vent well. The soil gas analytical measurements indicate that fuel biodegradation is progressing at a significant rate. For Site 388, AFCEE recommends that the bioventing pilot system continue to operate while planning for an expansion of the system for full-scale remediation. The radius of influence at each of the other three sites appears to be sufficient to cover the entire site. System expansion to a full-scale bioventing system at Site 388 can be contracted through AFCEE. Please contact Jerry Hansen, AFCEE/ERT, DSN 240-4353, COM 210-536-4353, to discuss technical and contractual options for full-scale expansion.

Data from your base and many others indicate that BTEX compounds are preferentially biodegraded over TRPH. Since BTEX compounds represent the most toxic and mobile fuel constituents, a BTEX standard is a risk-based standard. Within the AFCEE Risk-based Petroleum Hydrocarbon "Tool Box," the reported entitled "Use of Risk-based Standards for Cleanup of Petroleum Contaminated Soil," summarizes the BTEX/TPH issue and will assist you in negotiating for a BTEX cleanup standard.

In general, quantitative destruction of BTEX will occur over a one- to two-year bioventing period. Soil gas surveys and respiration tests can be used as BTEX destruction indicators. If a non-risk-based/TRPH cleanup is chosen, the pilot and full-scale systems should be operated until respiration rates approach background rates. We recommend that confirmatory soil sampling be conducted four to six months after background respiration rates are approached.

Because this is a streamlined test and evaluation project, our contract does not provide for additional reports to the base on pilot study results. The interim results report contains as-builts and initial data. This letter summarizes all data collected and provides next step recommendations. AFCEE is no longer responsible for the operation, maintenance, or monitoring of the bioventing systems. We have initiated a contract to extend monitoring at some sites beyond the initial one-year test. Monitoring includes soil gas and respiration tests to document hydrocarbon degradation and also includes the collection of sufficient final soil samples to statistically demonstrate site cleanup. If you are interested, please call us.

The blower and accessories are now base property and should continue to be used on this or other bioventing sites. Although current equipment is explosion proof,

under no circumstances should it be used for soil vapor extraction unless appropriate explosion-proof wiring is provided. If the base does not want the keep the blower or if you have further questions, please contact us.

On behalf of the AFCEE/ERT staff, I would like to thank you for your support of these bioventing test and evaluation projects. The information gained from each site will be invaluable in evaluating this technology and will promote its successful application on other DOD, government, and private sites. I have attached a customer satisfaction survey. Please take a few minutes to fill it out and tell us how we did. We look forward to hearing from you.

ROSS N. MILLER, Lt Col, USAF, BSC
Chief, Technology Transfer Division

Attachments:
1. Site 388 Data
2. Site 510.8 Data
3. Site 1705 Data
4. Site 40002 Data
5. Survey

cc: AFCEE/ERD (1Lt Aide)
AFMC/CEVR
Engineering Science

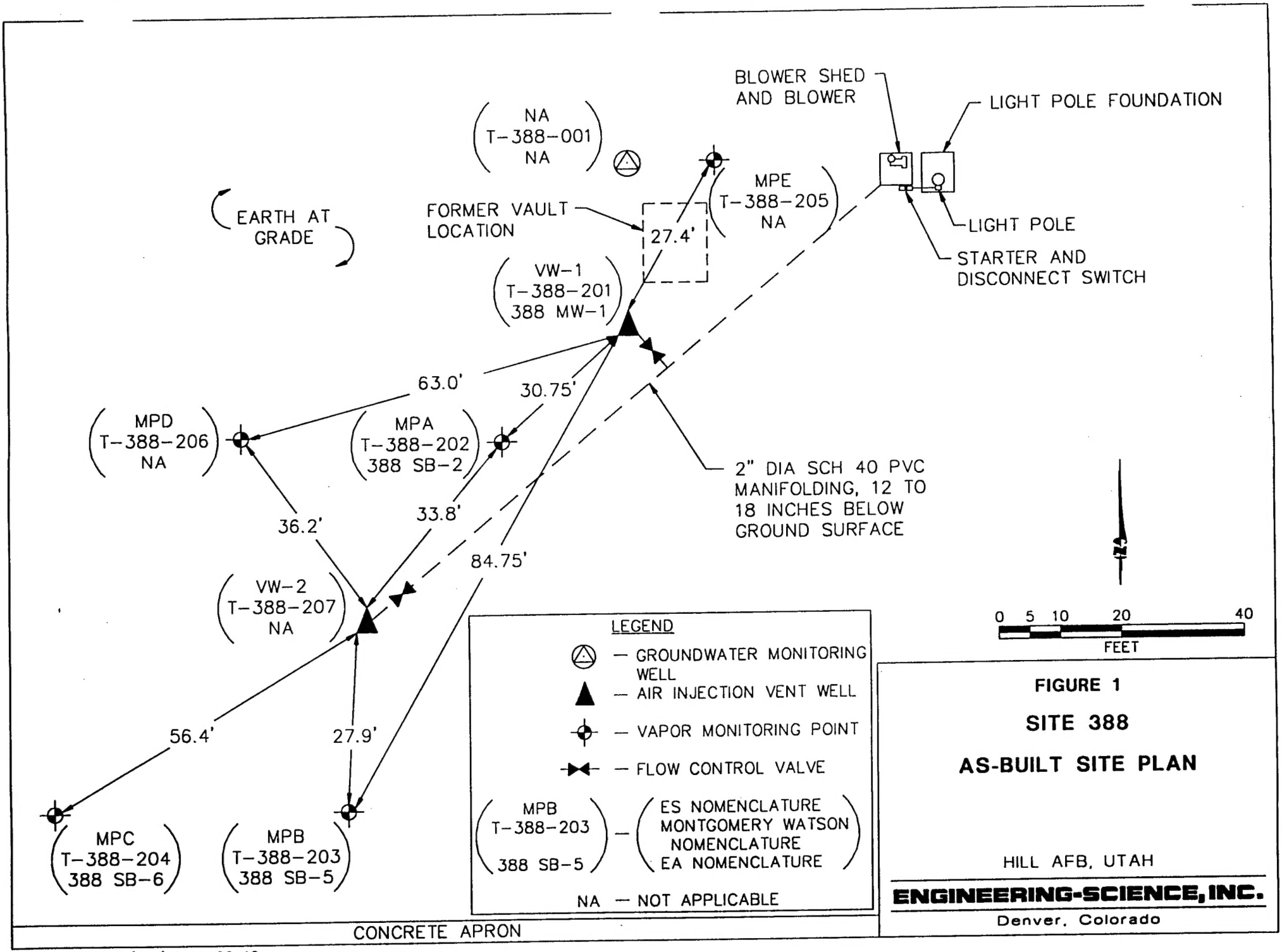


FIGURE 1

SITE 388

AS-BUILT SITE PLAN

HILL AFB, UTAH

ENGINEERING-SCIENCE, INC.

Denver, Colorado

93DN1125, 03/08/94 at 09:40

TABLE 1
SITE 388
RESPIRATION AND DEGRADATION RATES
HILL AFB, UTAH

Location–Depth (feet bgs)	Initial (July 1993)			6–Month (March 1994)			1–Year (Aug. 1994)		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW–1–25–75	0.00089	350	NS[b/]	NS	NS	NS	0.0096	3300	NS
MPA–75	0.021	8400	NS	0.00080	310	NS	0.0062	2400	NS
MPA–90	NS	NS	NS	0.00039	120	NS	0.0024	770	NS
MPB–94	NS	NS	NS	0.0013	420	NS	0.0083	2700	NS
MPD–100	0.0029	710	NS	0.00012	28	NS	0.00049	120	NS
MPE–14	NS	NS	NS	0.0049	730	NS	0.012	1800	NS
MPE–39	0.0033	710	NS	NS[c/]	NS	NS	NS[c/]	NS	NS

[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] VW and MPs were installed by other contractors; no thermocouples were installed; NS=Not sampled.
[c/] Soil gas samples could not be collected due to impermeable soils.

TABLE 2
SITE 388
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
HILL AFB, UTAH

Analyte (Units)[a/]	Sample Location-Depth (feet below ground surface)					
	VW-1-25-75		MPA-75		MPB-94	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	27,000	16	19,000	14,000	33,000	13,000
Benzene (ppmv)	210	<0.002	15	6.0	300	<1.5
Toluene (ppmv)	270	0.010	12	240	250	51
Ethylbenzene (ppmv)	15	0.019	3.3	34	8.5	42
Xylenes (ppmv)	160	0.12	15	390	66	380

	VW-1-34			MPE-27	
Soil Hydrocarbons	Initial[d/]	1-Year[e/]	1-Year[f/]	Initial[g/]	1-Year
TRPH (mg/kg)[h/]	13,900	36	0.70	730	3,160
Benzene (mg/kg)	7.67	0.0005	<0.0005	<1.1[i/]	<0.27
Toluene (mg/kg)	92.7	0.0013	0.0012	<1.1[i/]	<0.27
Ethylbenzene (mg/kg)	44.3	0.017	<0.0005	<1.1[i/]	1.6
Xylenes (mg/kg)	479	0.018	0.0032	9.35[i/]	12
Moisture (%)	11.6	6.7	7.4	5.7	6.5

[a/] TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume; TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
[b/] Initial soil gas samples collected on 7/20/93.
[c/] 1-Year soil gas samples collected on 8/2/94.
[d/] VW-1-34 initial soil samples collected by another contractor on 7/7/92.
[e/] 1-Year soil samples collected on 8/12/94; VW-1-34 soil sample collected from 34-35'.
[f/] VW-1-34 duplicate sample collected from 35-36'.
[g/] MPE-27 initial soil data collected by another contractor on 6/21/93.
[h/] TRPH analyzed by EPA Modified Method 8015.
[i/] Average of two duplicate laboratory analyses.

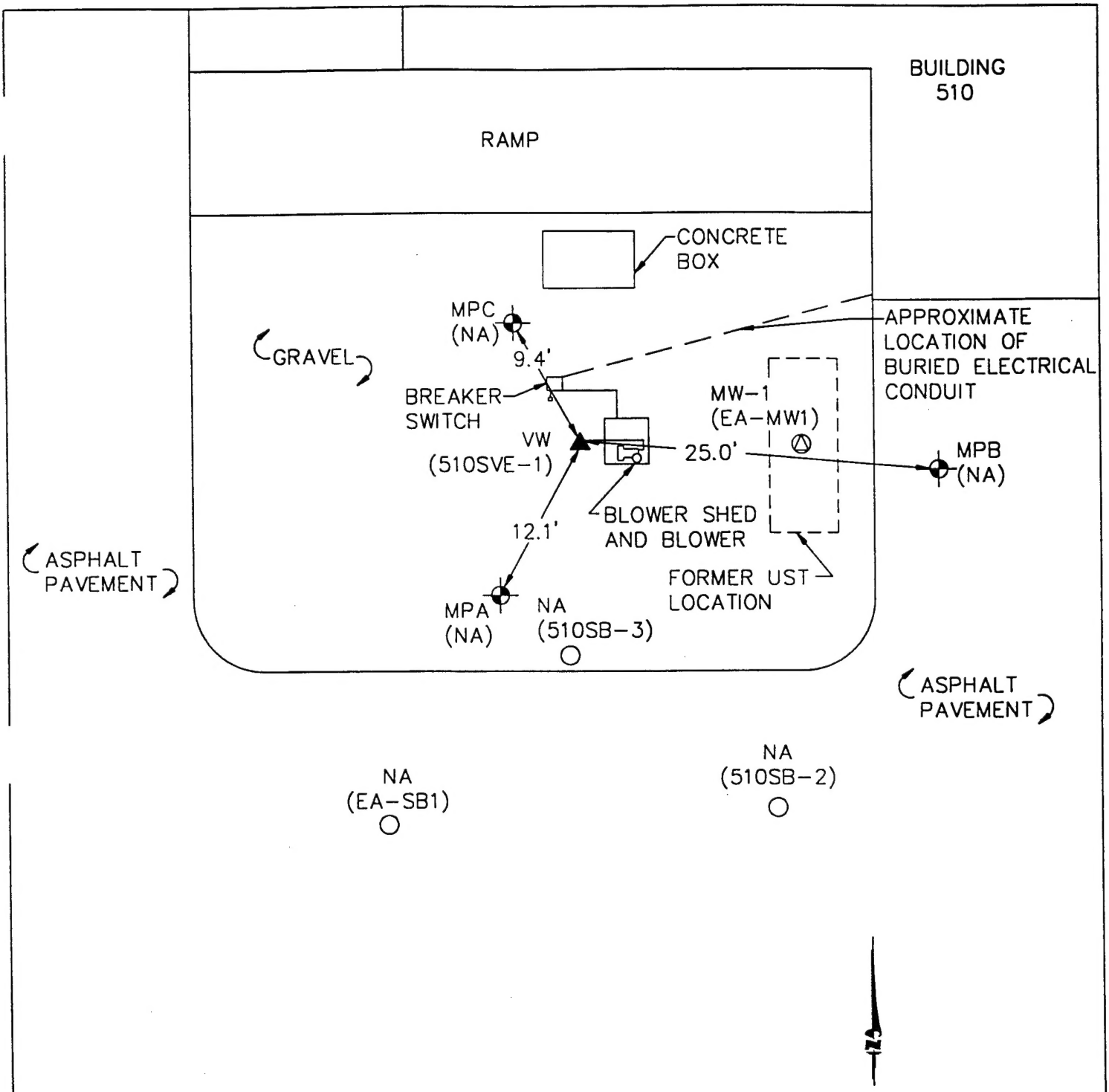


FIGURE 1

SITE 510.8

AS-BUILT SITE PLAN

HILL AFB, UTAH

ENGINEERING-SCIENCE, INC.

Denver, Colorado

93DN1126, 03/08/94 at 09:45

TABLE 1
SITE 510.8
RESPIRATION AND DEGRADATION RATES
HILL AFB, UTAH

Location–Depth (feet bgs)	Initial (Aug. 1993)			6–Month (March 1994)			1–Year (Aug. 1994)		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW–34–64	NS[b/]	NS	NS	0.00032	40	NS	NS	NS	NS
MPA–20	NS	NS	16.7	NS[c/]	NS	NS	NS	NS	20.0
MPA–40	0.00091	400	NS	NS[c/]	NS	NS	0.0047	1800	NS
MPA–50	0.00014	40	16.0	NS[c/]	NS	NS	0.00058	190	16.4
MPB–20	NS	NS	NS	0.00042	160	NS	0.0013	490	NS
MPB–35	0.00032	110	NS	0.000019	10	NS	0.00030	110	NS
MPC–40	NS	NS	NS	0.00072	270	NS	0.0017	640	NS
MPC–50	0.00010	20	NS	0.00025	60	NS	0.00047	150	NS

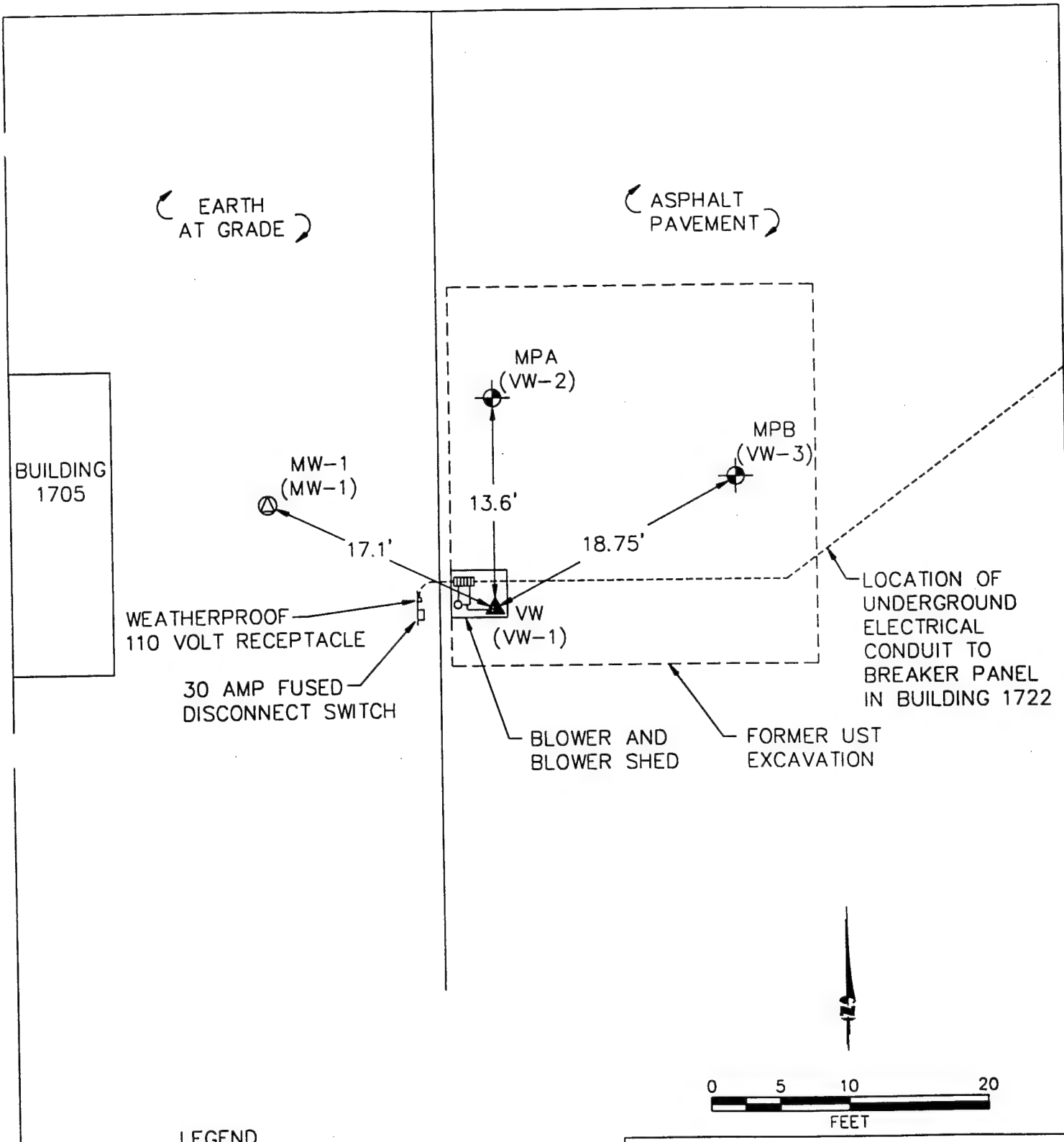
[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] NS=Not Sampled.
[c/] MPA paved over, inaccessible during 6 month test.

TABLE 2
SITE 510.8
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
HILL AFB, UTAH

Analyte (Units)[a/]	Sample Location-Depth (feet below ground surface)					
	VW-34-64		MPA-40		MPB-35	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	1100	23	760	1000	140	3.6
Benzene (ppmv)	<0.030	<0.002	<0.061	<0.012	<0.006	<0.003
Toluene (ppmv)	0.034	<0.002	0.13	<0.012	0.37	<0.003
Ethylbenzene (ppmv)	<0.030	<0.002	0.11	0.19	0.055	0.005
Xylenes (ppmv)	0.15	0.023	0.51	0.57	0.62	0.017

	VW-34		MPA-49		MPB-39		MPC-49	
Soil Hydrocarbons	Initial[d/]	1-Year[e/]	Initial[f/]	1-Year[g/]	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)[h/]	7,400	89	1,440	487.7	<5.3	NS	14,200	7,170
Benzene (mg/kg)	NS[i/]	<0.065	<0.08	<0.066	<0.0003	NS	<0.002	<0.068
Toluene (mg/kg)	NS	<0.065	<0.08	<0.066	<0.0003	NS	<0.002	<0.068
Ethylbenzene (mg/kg)	NS	<0.065	<0.08	<0.066	<0.0003	NS	<0.002	<0.068
Xylenes (mg/kg)	NS	<0.091	<0.2	<0.092	<0.0007	NS	<0.003	0.22
Moisture (%)	22.5	4.3	4.0	8.0	5.2	NS	15.0	8.4

[a/] TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
[b/] Initial soil gas samples collected on 8/11/93.
[c/] 1-Year soil gas samples collected on 8/1/94.
[d/] Initial sample for vent well was collected on 7/14/92 by another contractor and labeled as 510SVE-1(34).
[e/] 1-Year soil samples collected on 8/10/94.
[f/] Initial soil samples for MPs collected on 8/3/93, 8/6/93, and 8/9/93.
[g/] Average of two duplicate samples.
[h/] TRPH analyzed by EPA Modified Method 8015 for VW soil samples. MP soil samples were analyzed for TRPH by Method 418.1.
[i/] NS=Not Sampled.



LEGEND

MPA (VW-2) — ES NOMENCLATURE (RADIAN NOMENCLATURE)

⊘ — GROUNDWATER MONITORING WELL

▲ — AIR INJECTION WELL

⊕ — VAPOR MONITORING POINT

FIGURE 1

SITE 1705

AS-BUILT SITE PLAN

HILL AFB, UTAH

ENGINEERING-SCIENCE, INC.

Denver, Colorado

94DN0151, 03/07/94 at 14:40

TABLE 1
SITE 1705
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
HILL AFB, UTAH

Analyte (Units)[a/]	Sample Location-Depth (feet below ground surface)					
	VW-10-20		MPA-13		MPB-15.4	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	110	1.4	7.7	0.86	13	1.2
Benzene (ppmv)	0.024	<0.003	0.008	<0.003	0.004	<0.003
Toluene (ppmv)	0.035	0.002	0.014	<0.003	0.007	0.004
Ethylbenzene (ppmv)	0.025	0.002	<0.002	<0.003	0.006	<0.003
Xylenes (ppmv)	0.14	0.035	0.007	0.028	0.013	0.041

	VW-10	VWA-10[d/]	VWB-10[d/]	VWC-10[d/]
Soil Hydrocarbons	Initial[e/]	1-Year[f/]	1-Year	1-Year
TRPH (mg/kg)[g/]	13,200	<4.5	<4.1	1,790
Benzene (mg/kg)	<0.025	<0.0005	<0.0005	<0.0005
Toluene (mg/kg)	<0.025	<0.0005	<0.0005	<0.0005
Ethylbenzene (mg/kg)	<0.025	<0.0005	<0.0005	<0.0005
Xylenes (mg/kg)	0.36	<0.0007	<0.0007	<0.0007
Moisture (%)	8.3	10.6	3.0	5.4

a/ TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
b/ Initial soil gas samples collected on 7/14/93.
c/ 1-Year soil gas samples collected on 8/2/94.
d/ Probe location was within 5 feet of the VW.
e/ Initial soil samples collected on 11/11/92 and 11/12/92.
f/ 1-Year soil samples collected on 8/9/94.
g/ TRPH analyzed by EPA Modified Method 8015.

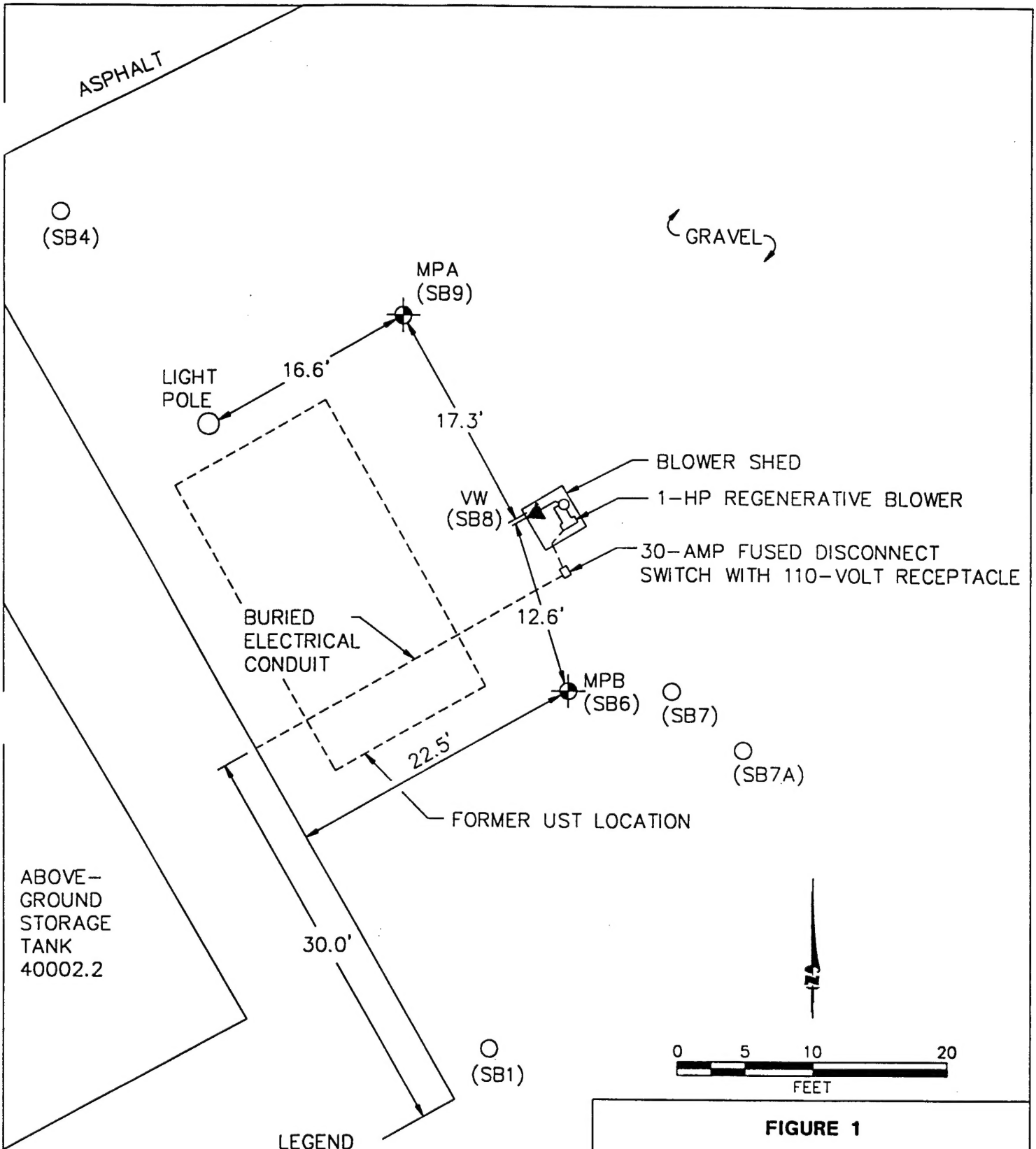


FIGURE 1

SITE 40002

AS-BUILT SITE PLAN

UTAH TEST AND TRAINING RANGE

HILL AFB, UTAH

ENGINEERING-SCIENCE, INC.

Denver, Colorado

93DN1123, 03/07/94 at 14:30

TABLE 1
SITE 40002
RESPIRATION AND DEGRADATION RATES
UTAH TEST AND TRAINING RANGE
HILL AFB, UTAH

Location–Depth (feet bgs)	Initial (July 1993)			6–Month (March 1994)[b/]			1–Year (August 1994)		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW (5–45)	0.0021	470	NS[c/]	NS	NS	NS	0.00048	59	NS
MPA–17	0.0072	210	NS	0.00020	36	NS	0.0047	1600	NS
MPA–32	0.0028	570	NS	0.00015	70	NS	0.00026	130	NS
MPB–16	0.0052	530	NS	NS	NS	NS	0.0018	610	NS
MPB–32	0.00090	170	NS	0.00015	68	NS	0.00025	120	NS
T–40002–202 (27–28)	NS[d/]	NS	NS	0.00053	260	NS	0.00084	420	NS

[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] Assumes moisture content of the soil is average of initial and final moistures.
[c/] No thermocouples were installed. NS=Not Sampled.
[d/] Monitoring point was installed by another contractor 8/24/93.

TABLE 2
SITE 40002
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
UTAH TEST AND TRAINING RANGE
HILL AFB, UTAH

Analyte (Units)[a/]	Sample Location-Depth (feet below ground surface)					
	VW-5-45		MPA-17		MPB-16	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	20,000	52	12,000	21,000	1,300	2,200
Benzene (ppmv)	<1.1	0.11	<2.3	<6.0	<0.12	<1.2
Toluene (ppmv)	240	1.1	290	420	8.3	4.3
Ethylbenzene (ppmv)	26	0.44	8.8	24	0.68	4.8
Xylenes (ppmv)	220	2.9	100	380	16	64
	VW-14.5		MPA-14.5		T-202-16	
Soil Hydrocarbons	Initial[d/]	1-Year[e/]	Initial[d/]	1-Year	Initial[f/]	1-Year
TRPH (mg/kg)[g/]	60,600	18,800	23,400	16,300	140[h/] ; 310[i/]	1,860
Benzene (mg/kg)	127	5.5	13.4	67	<1.9	23
Toluene (mg/kg)	1,060	12	352	840	6.0	380
Ethylbenzene (mg/kg)	333	41	144	54	15	140
Xylenes (mg/kg)	2,309	670	1,444	2,120	45	950
Moisture (%)	12.0	29.6	23.2	34.2	35.3	17.1

[a/] TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
[b/] Initial soil gas samples collected on 7/26/93.
[c/] 1-Year soil gas samples collected on 8/3/94.
[d/] Initial soil samples collected on 11/18/92 and 11/19/92.
[e/] 1-Year soil samples collected on 8/11/94.
[f/] Initial soil sample collected on 8/24/93.
[g/] TRPH analyzed by EPA Method 8015.
[h/] Total Extractable Petroleum Hydrocarbons.
[i/] Total Volatile Petroleum Hydrocarbons.

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